Mackinaw Ice Trials Planning

Shipyard Meeting

June 21, 2004

Measurement Objectives

- Ship Performance
- Video Ice Surveillance
- Propulsion Plant Control
- Power Quality
- Hull-Ice Impact Pressures along the Ship Length
- Ice Loads on the Podded Propulsors

Ship Performance Measurements

- Shaft Thrust – From Pod Loads System
- Motor/Shaft Power – From Control System
- Shaft Torque – From Power & Shaft Speed
- Shaft Speed – From Control System
- Ship Speed and Position – From GPS
- Pod Orientation – From Control System

Video Ice Surveillance

- Ice Thickness Where Pieces Turn Up at the Side
- Ice Conditions and Track Ahead and Astern
- Underwater Video – Propeller/Pod Ice Interaction
- On-Ice Calibration of Cameras During the Trials

Propulsion Control Measurements

- Rack Position – Yo yo Potentiometer
- Generator Shaft Speed, Power, Current, Voltage, Power Factor – From Control System and Optical Tach
- Motor Power Shaft Speed, Voltage, Current – From Control System
- Throttle Position – From Control System

Power Quality Measurements

- Bus Voltage – From Control System
- Bus Frequency – From Control System
- THD – From Installed Voltage Divider on Main Bus & Directly on Sensitive Bus with Dranetz-type measurement system

Hull Loads Measurements

- Bow/Side/Stern Area
  - Along One Side from the Forward Shoulder to Aft Shoulder
  - Measure Deck between Frames in Every Other Frame Bay and on Multiple Waterlines on Bulkheads
  - Expect High Loads Because of Increased Maneuverability, Especially Near Stern Quarter

Azipod Load Measurements

- Lateral and Longitudinal Loads on the Pod Foundations exerted by the Pods – Bottom Plating and First Platform in the Void Space
- Lateral and Longitudinal Bending Moment on the Pod Foundations exerted by the Pods – Same as Above
- Spindle Torque –Steering Motor Hydraulic Pressure

Instrumentation Systems

- Pod Loads
- Propulsion Control, Performance and Power Quality
- Bow/Side/Stern Loads – 1 or 2 Systems
- Video Ice Surveillance System
- All Systems Connected to a Master Control Station through a Dedicated Fiber-Optic Network

Objectives of This Visit

- Discuss Interfaces with Ship Systems
- Determine Location of Instrument Racks
- Determine Cable Runs and Bulkhead/Deck Penetrations
- Discuss Feasibility of Piggy-Backing on Ship's Fiber-Optic Backbone or Installing Additional Cable Runs
- Discuss Location of a Master Control Station – On Deck Lab Van for Test Team

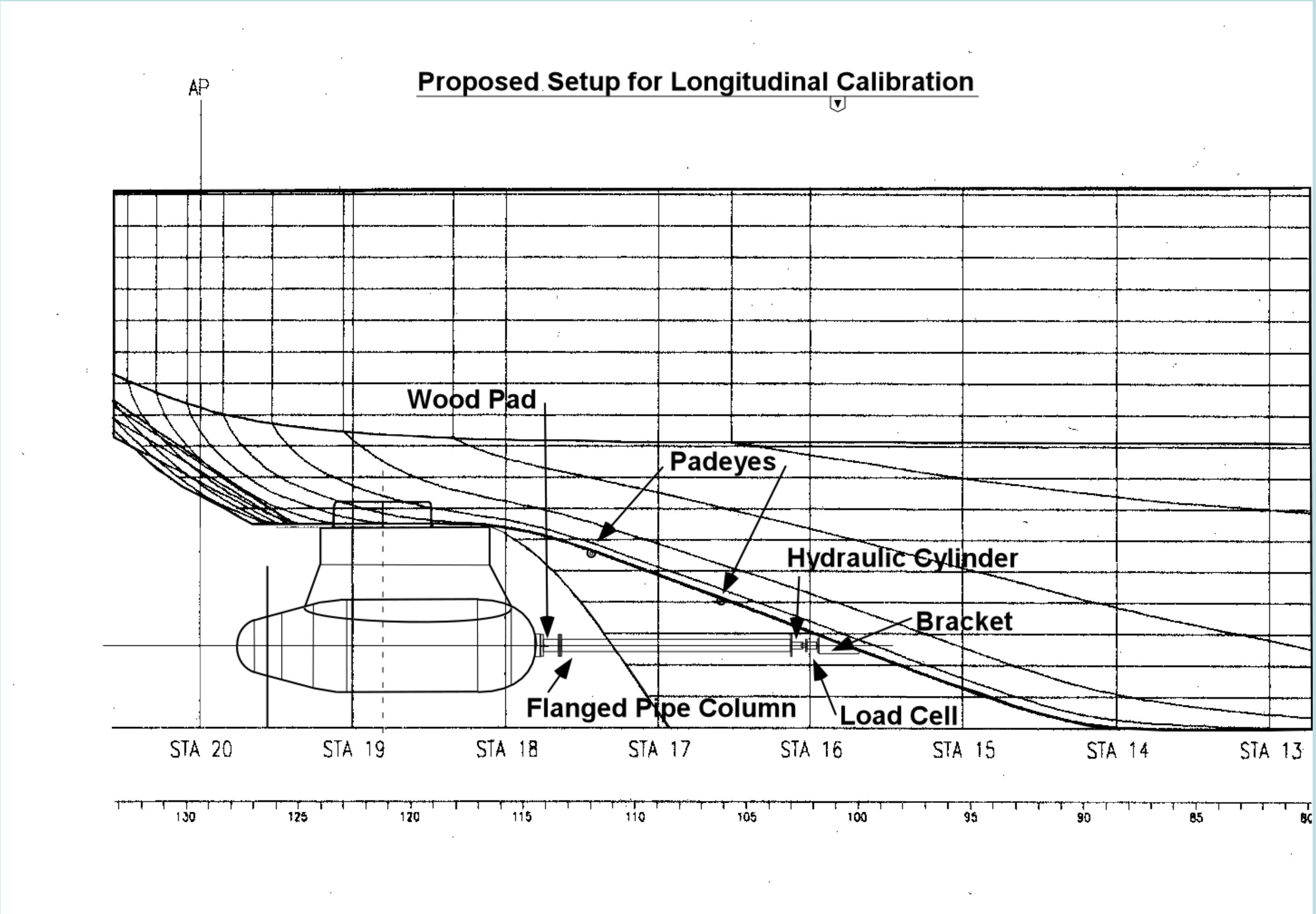
Objectives of This Visit

- Discuss Installation of Voltage Dividers on the Main Bus for THD measurements
- Discuss Proposed Calibration Scheme for Pod Loads
- Discuss Underwater Video Camera and Light Installation

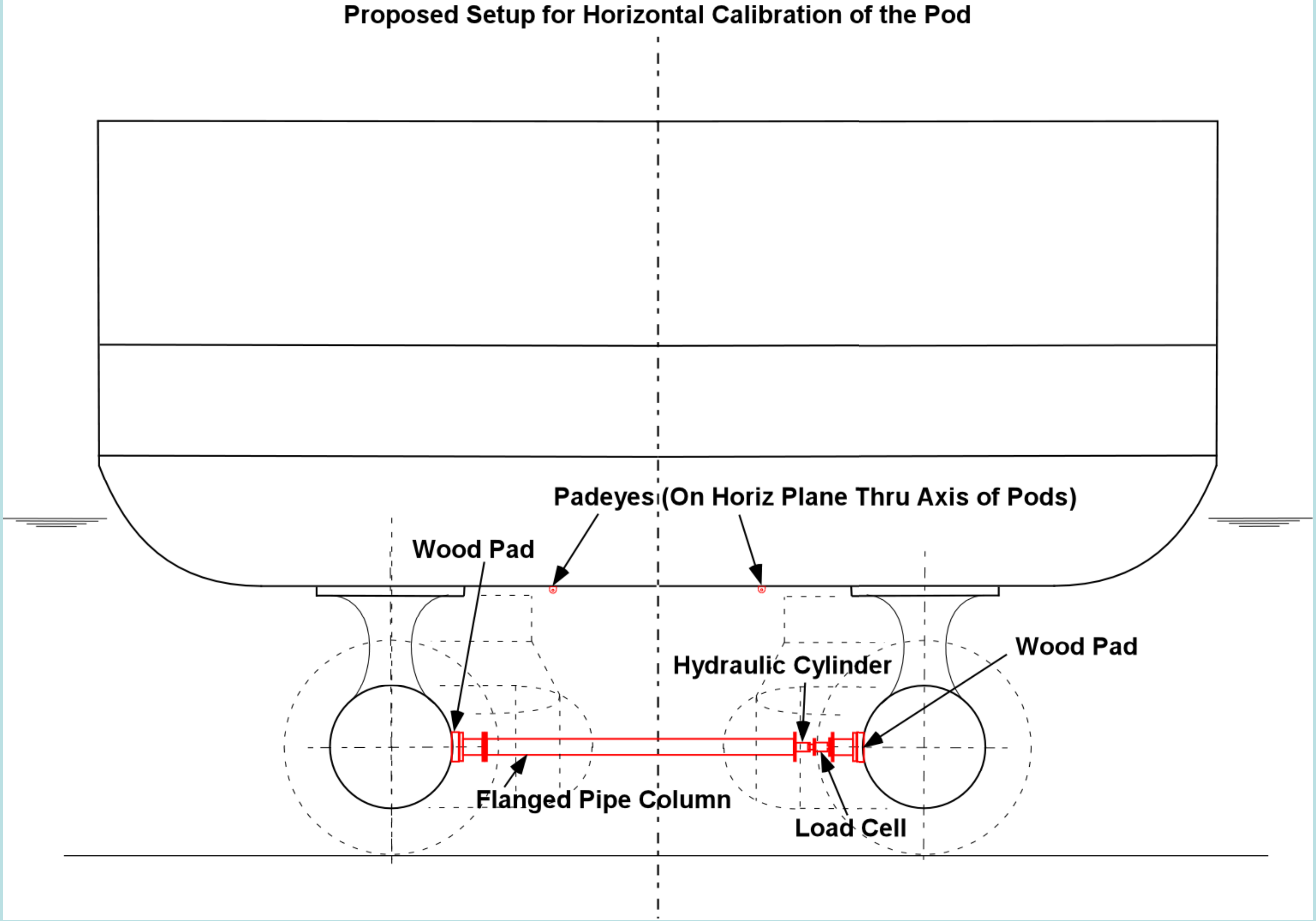
Calibration of Pods

- Hull mounted bracket to perform longitudinal calibration
- Jacking between the pods to perform lateral calibration
- Three pairs of gauges calibrated
- FEM comparison with physical calibration to determine calibration of other pairs

Longitudinal Calibration



Horizontal Calibration

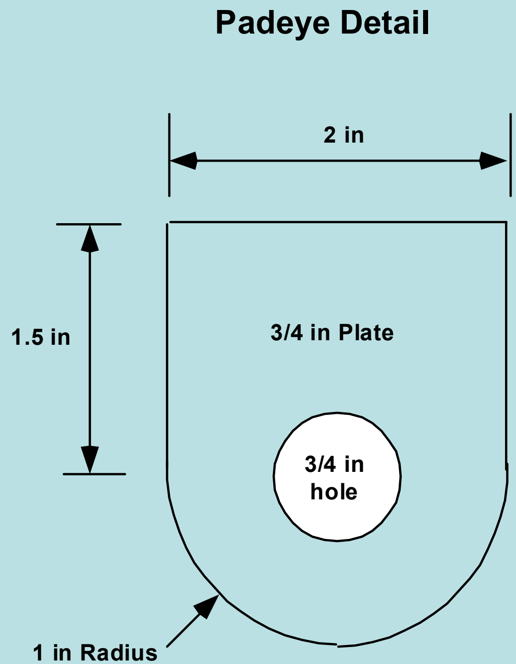


Design Aspects

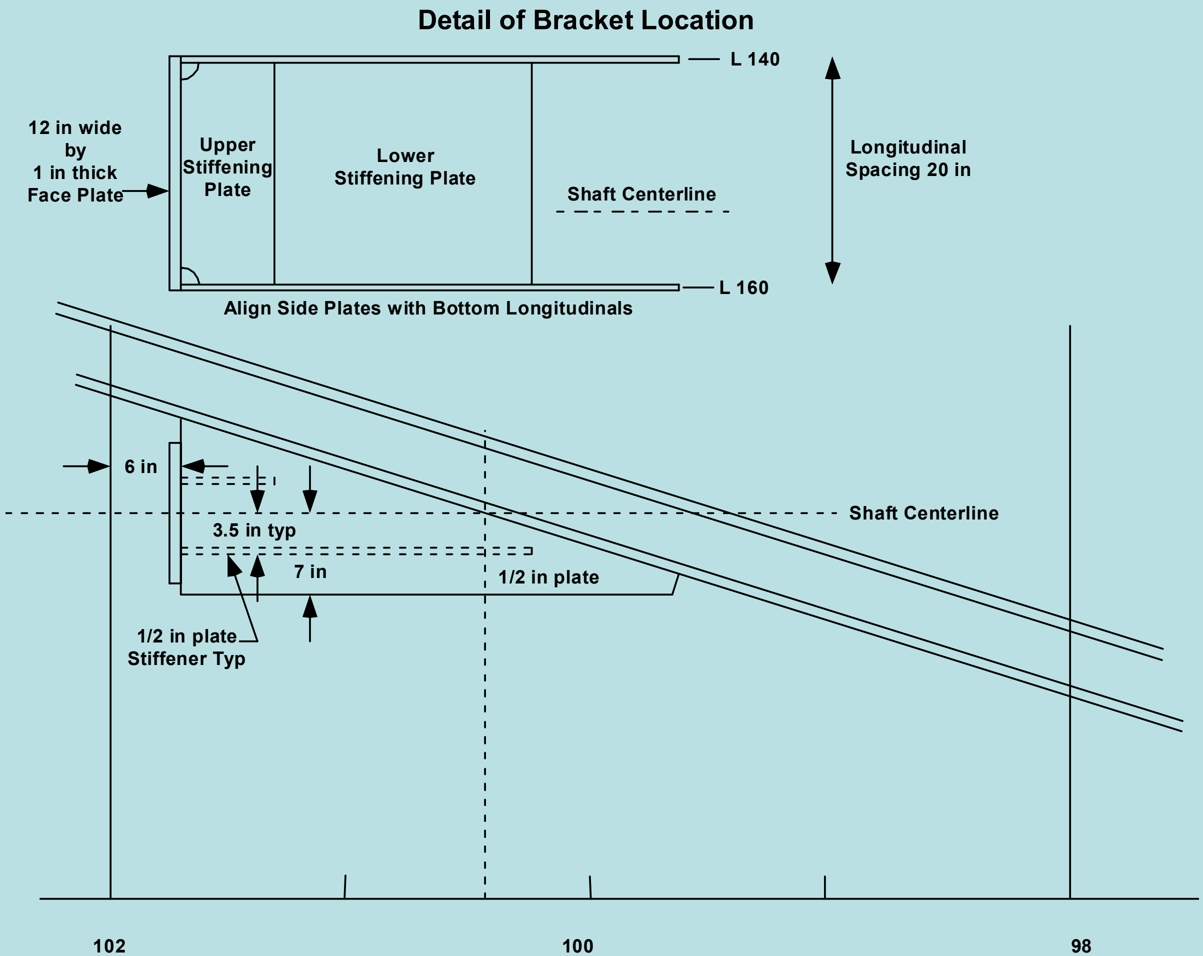
- Applied load in increments up to 40 LT
- System design for 200,000 lb
- 120,000 lb hydraulic cylinder
- Load cell accuracy +/- 0.1%
- Continuous recording of load simultaneous with strain gauge response
- Shaped pads to fit the pod hull shape designed to load hull at 200 psi at full load

Installation in the Yard

- Bracket for longitudinal calibration
- 4 padeyes to support calibration rig



Bracket Detail



Issues

- Shipyard to Install Bracket and Padeyes Prior to Launch
- STC will build calibration equipment
- Must be trucked to the drydock and lifted in by crane
- Padeyes will be used to hoist the calibration rig in place using chain hoists
- Longitudinal Calibration on Back of Pod Opposite to Propeller

Calibration Issues

- Wood Pads Machined to the Shape of the Pod
- Estimate the Rig will be 11 ft above the Drydock Deck during Operation – Need Scaffolding – Is it Available or Do We Provide?
- Bracket & Padeyes Burned Off In Drydock After Calibration Completed

Camera/Light Considerations

- Two Different Through-Hull Systems Considered
  - Deep Sea Systems – Designed for Through-Hull
  - Kongsberg – ROV Type – must be mounted for Through-Hull

Deep Sea Light & Camera

- Through-hull mounted design
- 250 W metal halide light – no filament to break
- Daylight light quality
- Color camera rated at 0.2 lux
- Extremely strong Sapphire ports
- Easy bolt-on installation
- Lowest initial cost and installation

Kongsberg Light & Camera

- ROV type equipment design to be submerged
- Camera is black & white rated at 0.004 lux – great low light capability
- Must have a port light to mount camera inside the hull
- 100 W halogen light must be submerged to dissipate heat
- Light can be used with a reostat to lower intensity

Visibility for Camera Operations

- Visibility was checked with divers that work in Lake Superior and the St Mary's River
  - 75 ft of visibility typical in the open lakes
  - 15 ft visibility in the river due to increased turbidity
- Light level should be reduced in turbidity
- Cone of light should intersect viewing cone of camera as little as possible – axis offset at about 90 deg

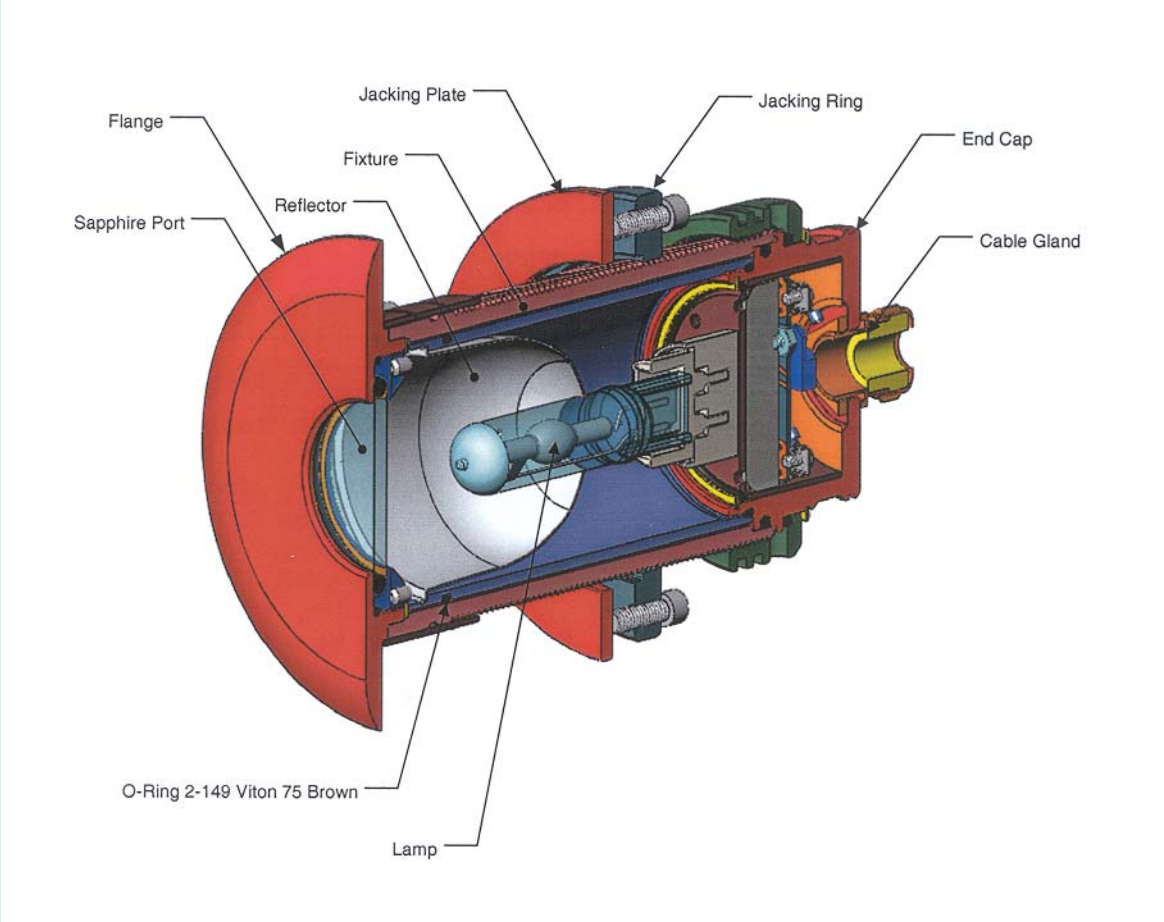
Camera/Light Mounting

- 8 in pipe housing welded as a through hull housing
- Plate welded in the pipe to mount the through-hull camera/light or port
- Inboard end of the pipe has an standard flange and pipe blank for secondary watertight boundary
- Blank can be removed to service equipment

Proposed Equipment

- Kongsberg Camera
  - Best low light capability
  - Borosilica port fused to a metal ring – high strength & bolt on installation
  - Camera mounts on blank for easy removal & servicing
- Deep Sea Metal Halide Light
  - Highest light output
  - Dissipate heat through the integral port
  - Strong port and light is resistant to vibration

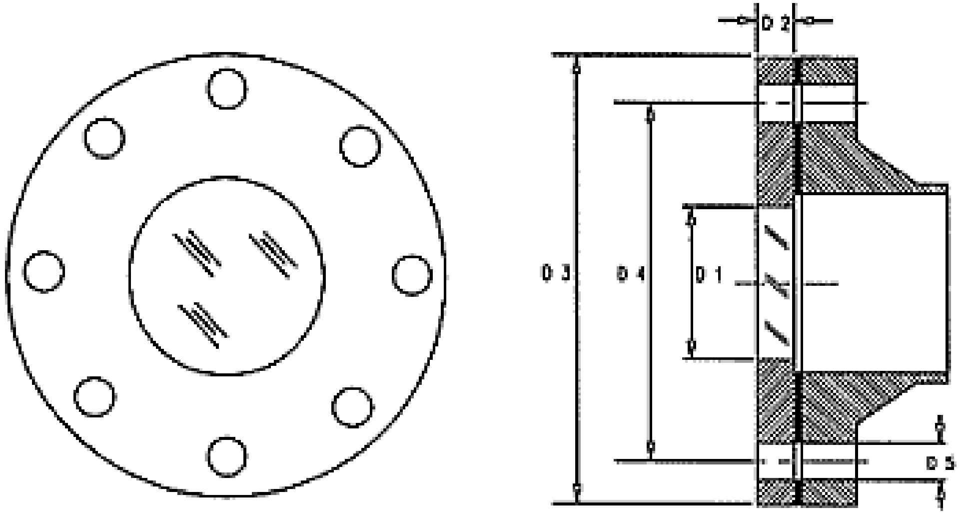
Deep Sea Light



Kongsberg Camera

MetaGlas Port for Camera

DWG. NO. 13A15



ANSI NOMINAL SIZE	RECOMMENDED ANSI PRESSURE CLASS . 150 PSI					
	NOTE: FULL FACE GASKETS REQUIRED					BOLT HOLES
	D 1	D 2	D 3	D 4	D 5	
	INCH	INCH	INCH	INCH	INCH	QUANTITY
1 1/2"	1.57	0.63	5.0	3.88	0.52	4
2"	1.97	0.80	6.0	4.75	0.75	
2-1/2"	2.60	0.80	7.0	5.50	0.75	
3"	2.95	0.80	7.5	6.0	0.75	
4"	4.00	0.80	9.0	7.50	0.75	8
6"	5.50	1.00	11.0	9.50	0.88	
8"	6.30	1.00	13.50	11.75	0.88	

SIGHT GLASS FUSED TO METAL CONFORMING DIN 7079

GLASS: BOROSILICATE (DIN 7080)

PRESSURE/TEMPERATURE CHARTS FOR EACH DISC SIZE IS AVAILABLE UPON REQUEST

RING MATERIAL	MAXIMUM WORKING TEMP.
Carbon Steel (1.0570)	535°F (280°C)
Duplex Stainless Steel (1.4462)	535°F (280°C)
Hastelloy C-4 (2.4610)	535°F (280°C)

CHANGE	DESCRIPTION OF CHANGE	DATE	NAME

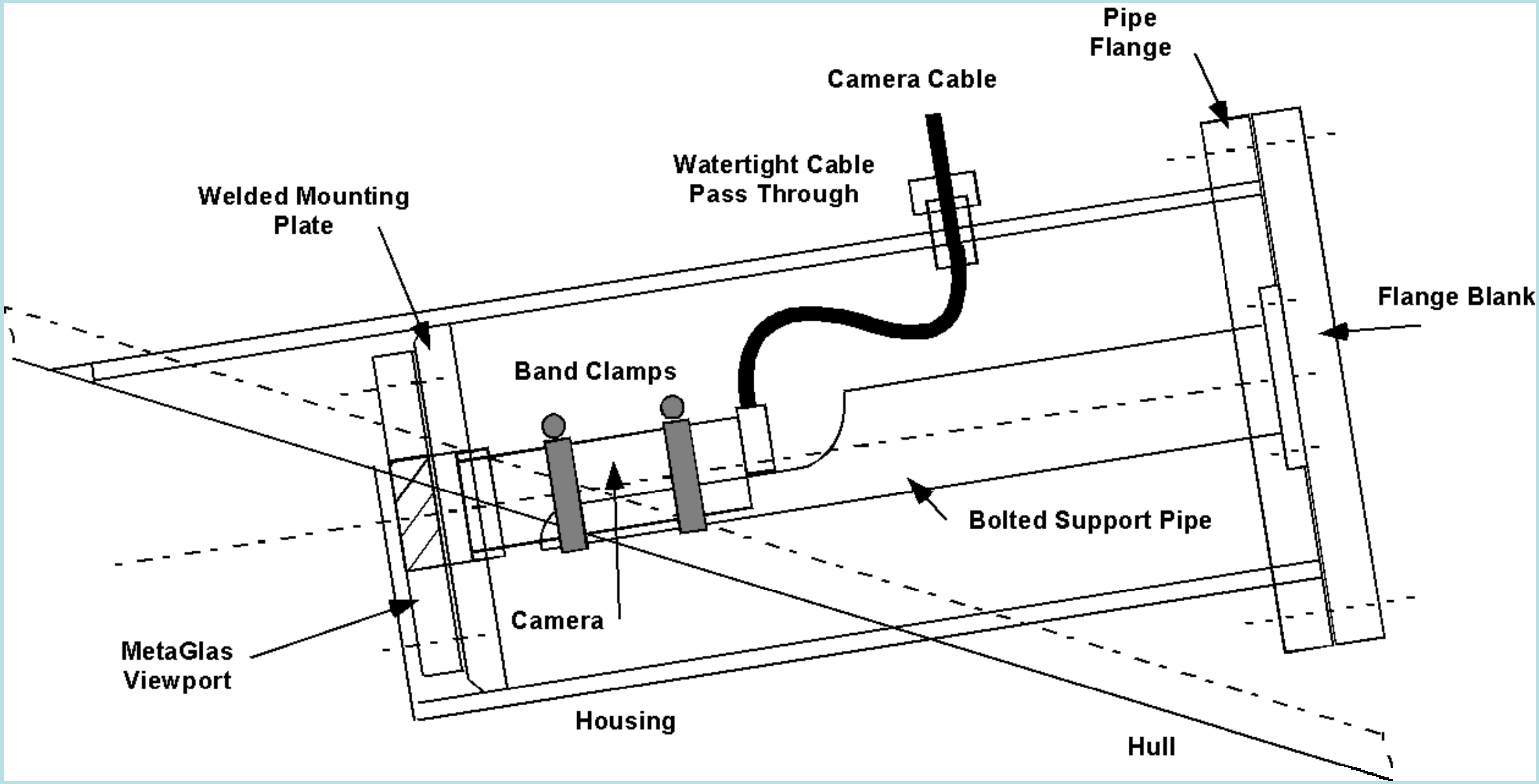
MANUFACTURED BY:

Herberts Industrieglas GmbH & Co. KG
GEWERBESCHULSTRASSE 72
D-42289 WUPPERTAL GERMANY

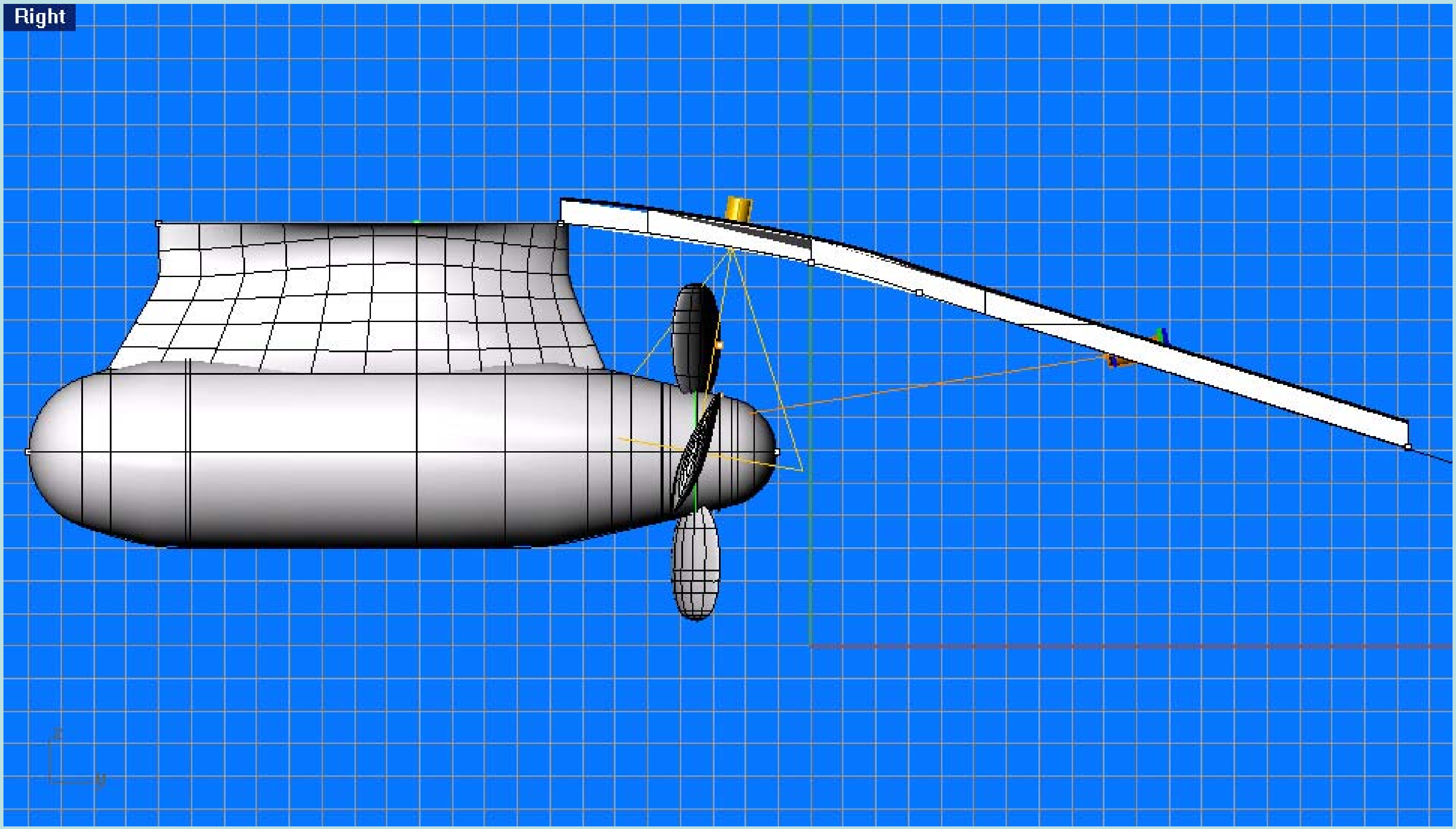
METAGLAS®
SIGHT GLASS DISC
PER ANSI B16.5

L. J. STAR INCORPORATED
2200 PINNACLE PARKWAY
P.O. BOX 1136
TWINSBURG, OH 44087
(330) 405-3040 • FAX (330) 405-3070

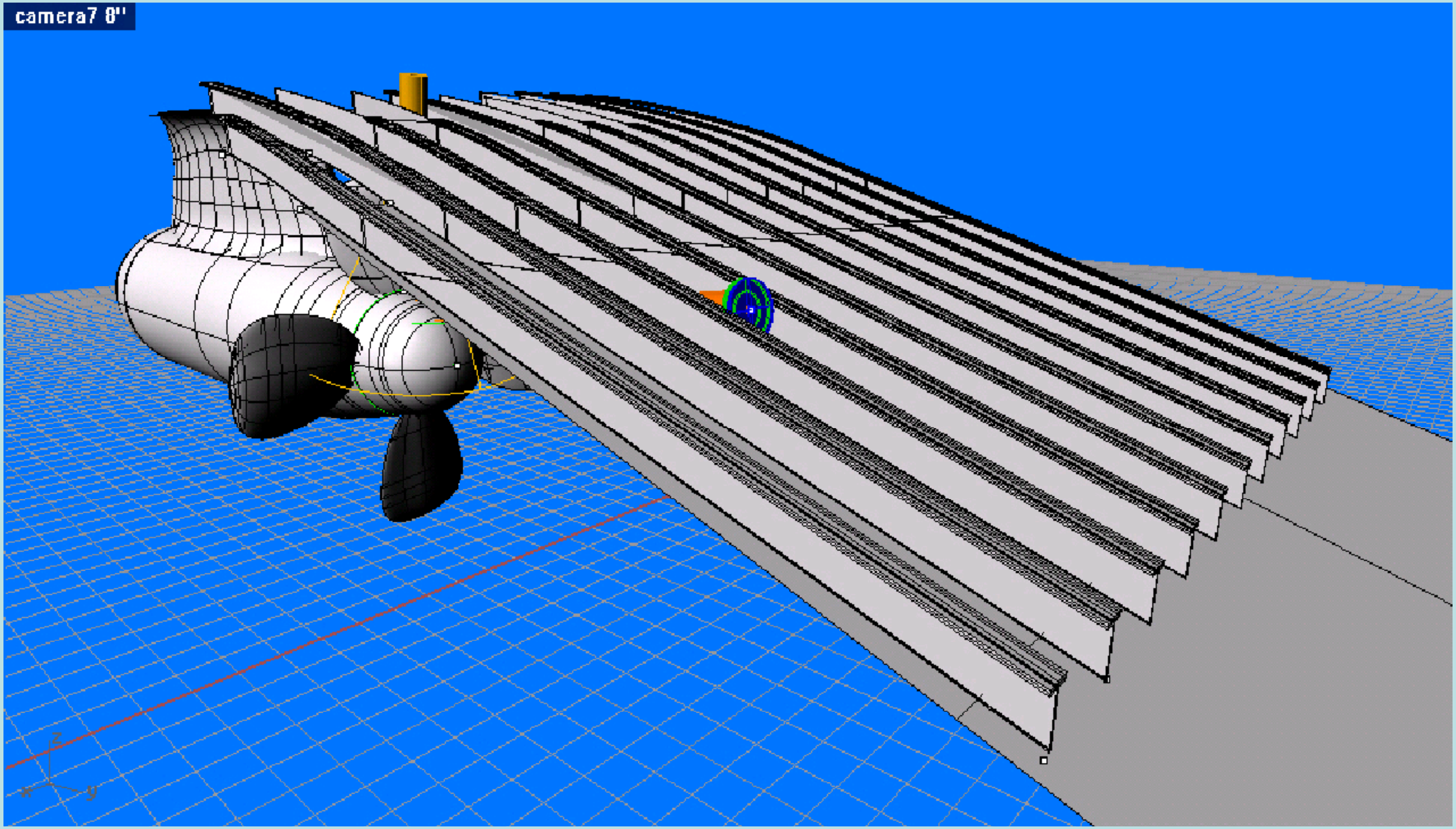
Port Light Detail



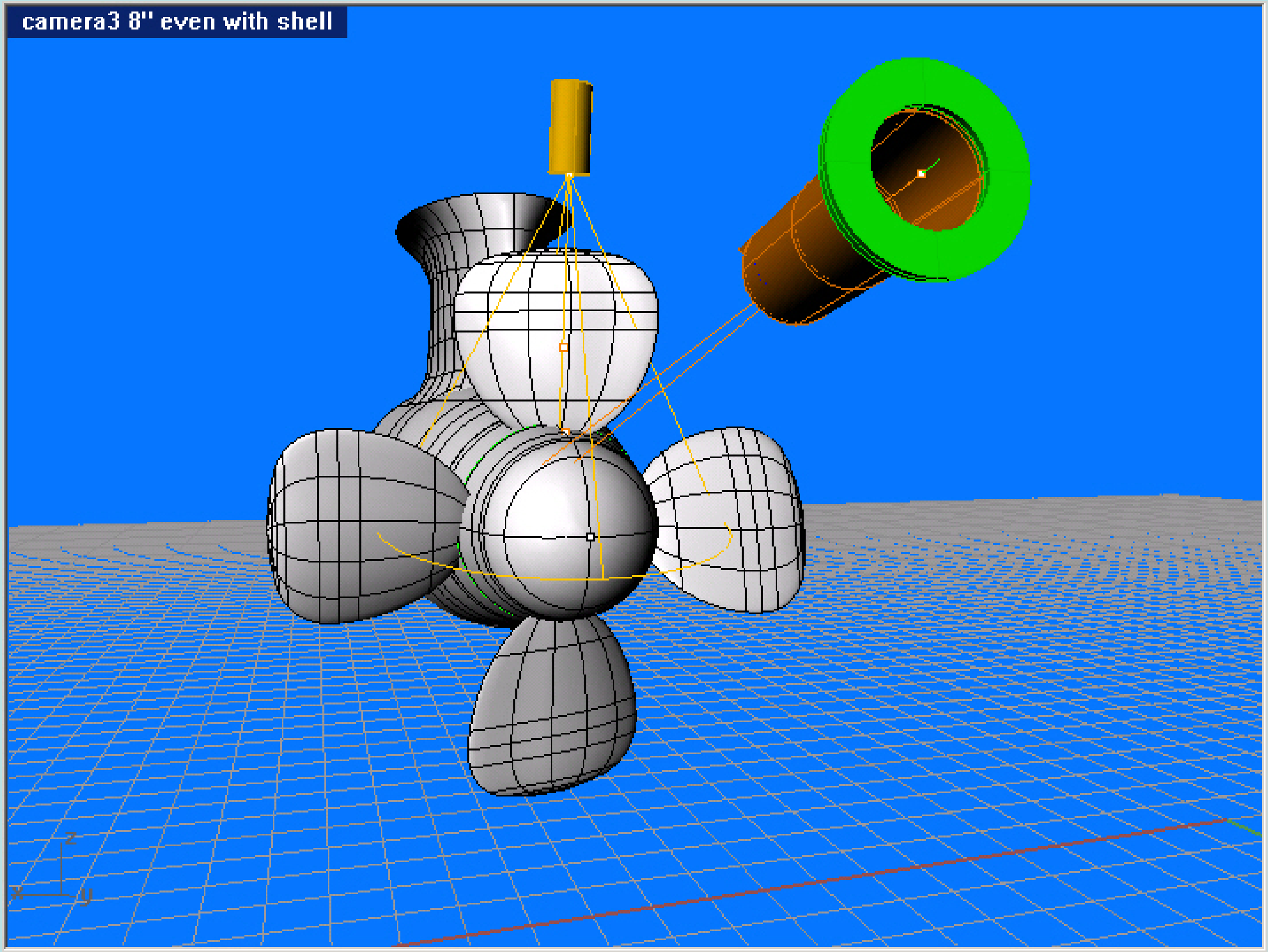
3-D Model of the Camera Layout



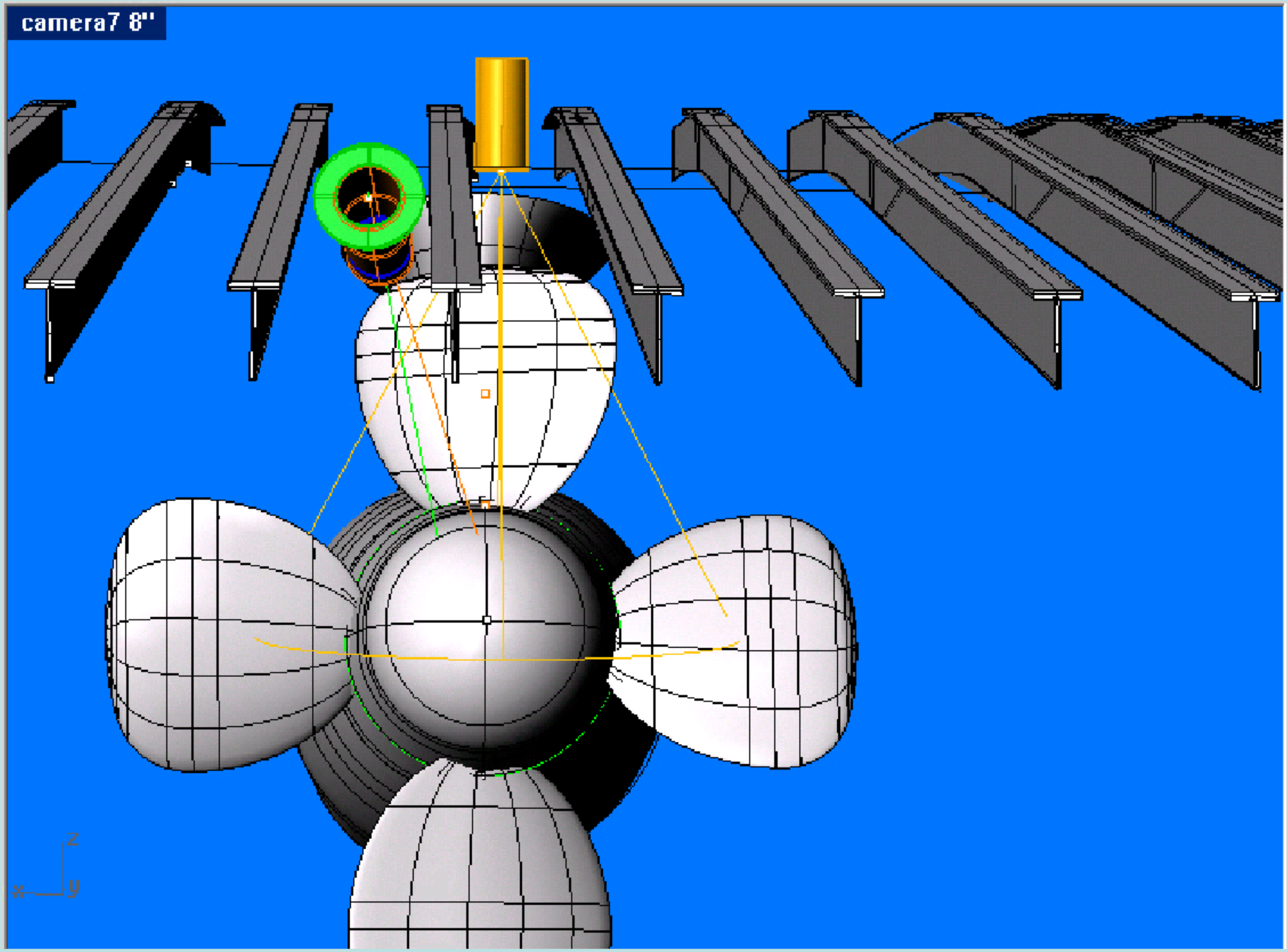
Isometric View



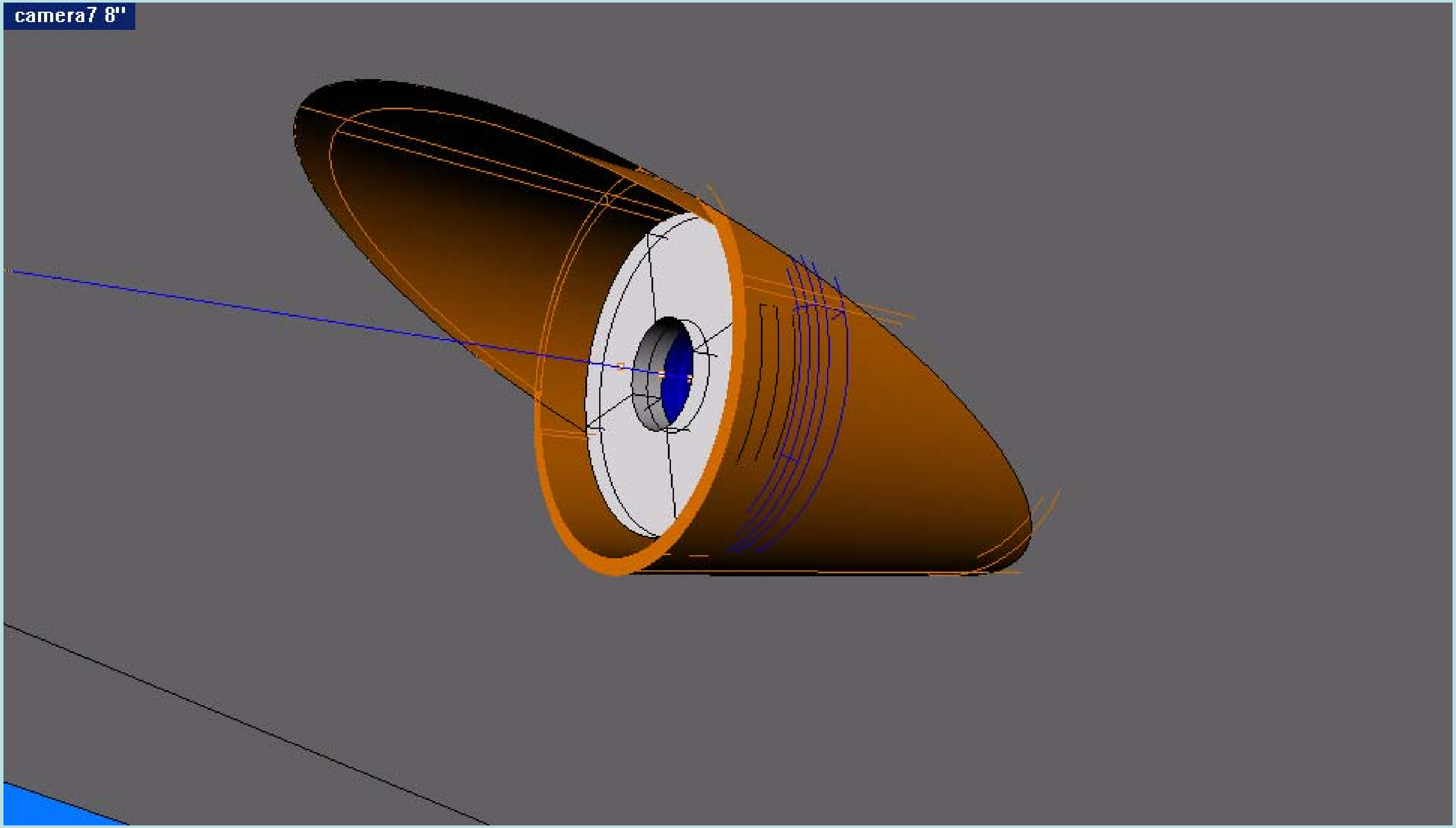
Isometric View of Camera & Light



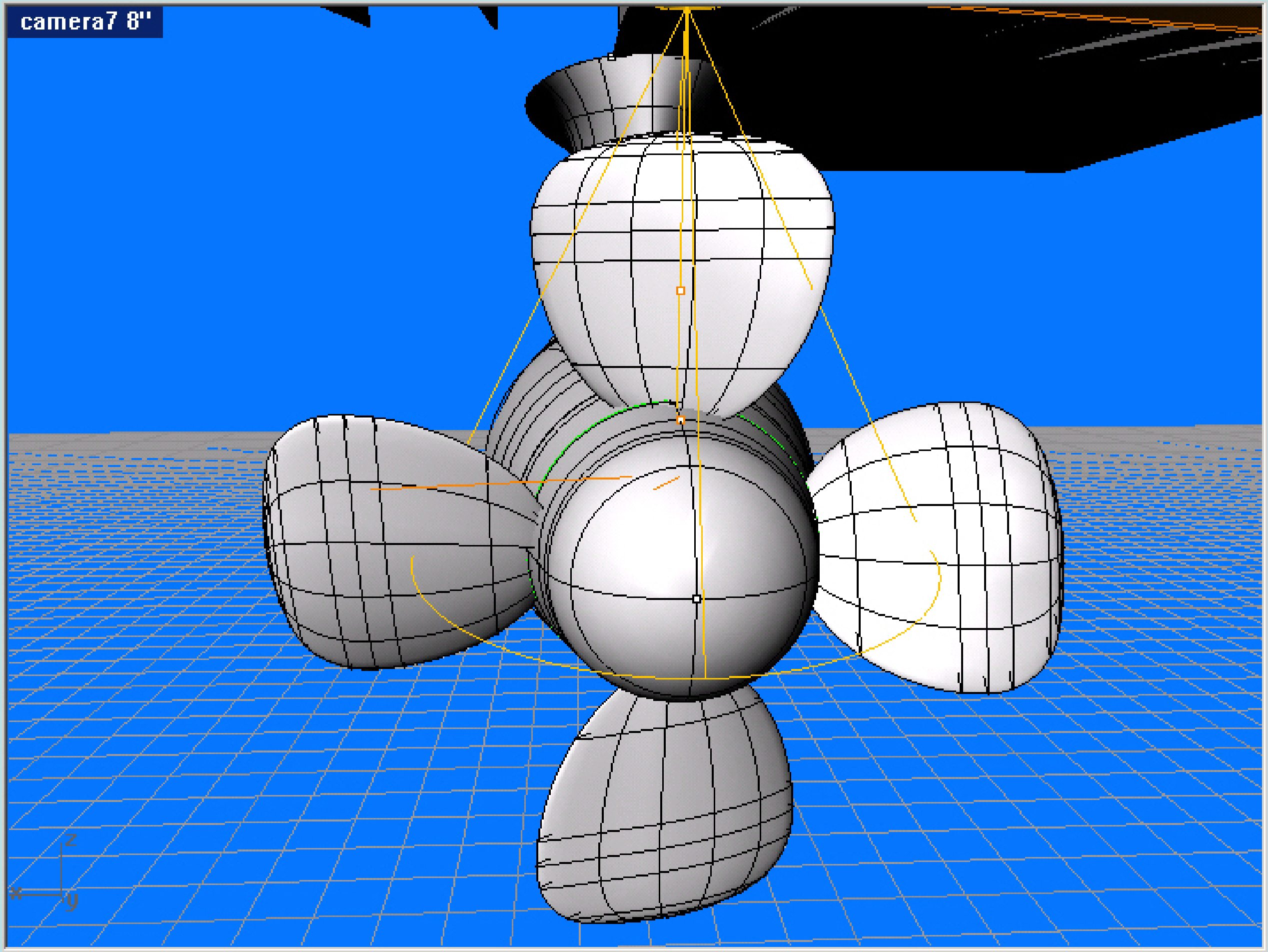
View of Housings Between Frames



Detail of Camera Housing



View from Camera



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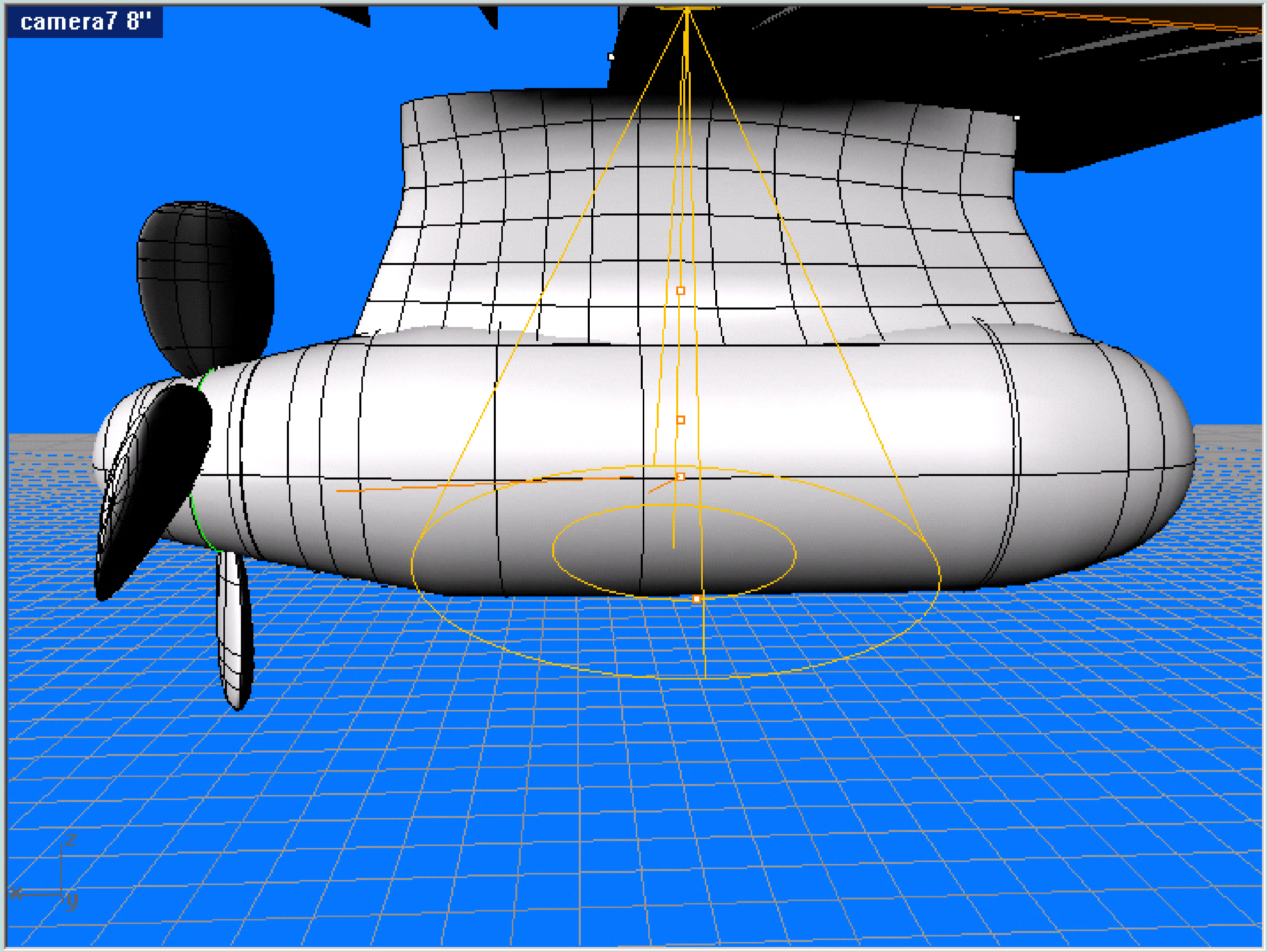

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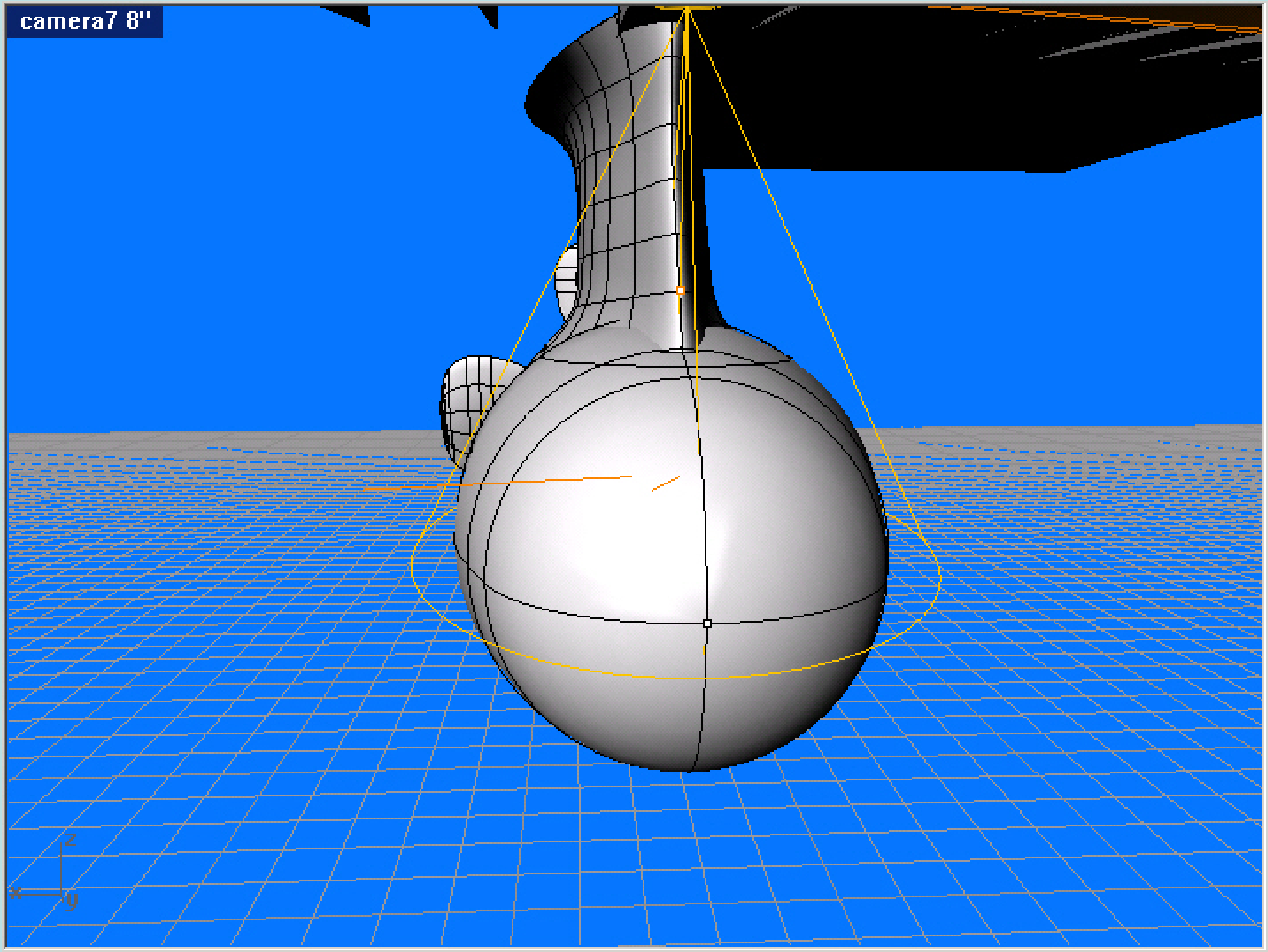

Positions of Housings

	Center of Pipe on Inside of Hull		Orientation Angle When Looking Down Camera Axis	
	Off CL (in)	From Fr 113 (in)	Off Longitudinal Plane (deg, +inbd)	Off Horizontal Plane (deg, +down)
Camera	169	111.5 fwd	3.5	9
Light	150.5	29.0 aft	0	80

Issues

- Must be Installed before Launch
- Assume a Permanent Installation
- ELC can Provide Housings/Equipment and Support Installation with Shipyard
- Requires Power Switches Outside of Void Space
- Requires Video Connection Outside of Void Space

Summary – Shipyard Work

• Install camera & light	• Concept defined
• Install calibration bracket & padeyes	• Concept defined – structural sketches
• Install rack foundations	• Concept started
• Install kick tubes for temporary cable runs	• To be defined
• Install voltage dividers	• To be defined

Summary – Shipyard Work

- Need for additional fiber-optic runs
- Temporary power to a lab van on deck
- Test team connections to shipboard systems

- To be defined
- To be defined
- Concept mostly defined by MPCMS database number